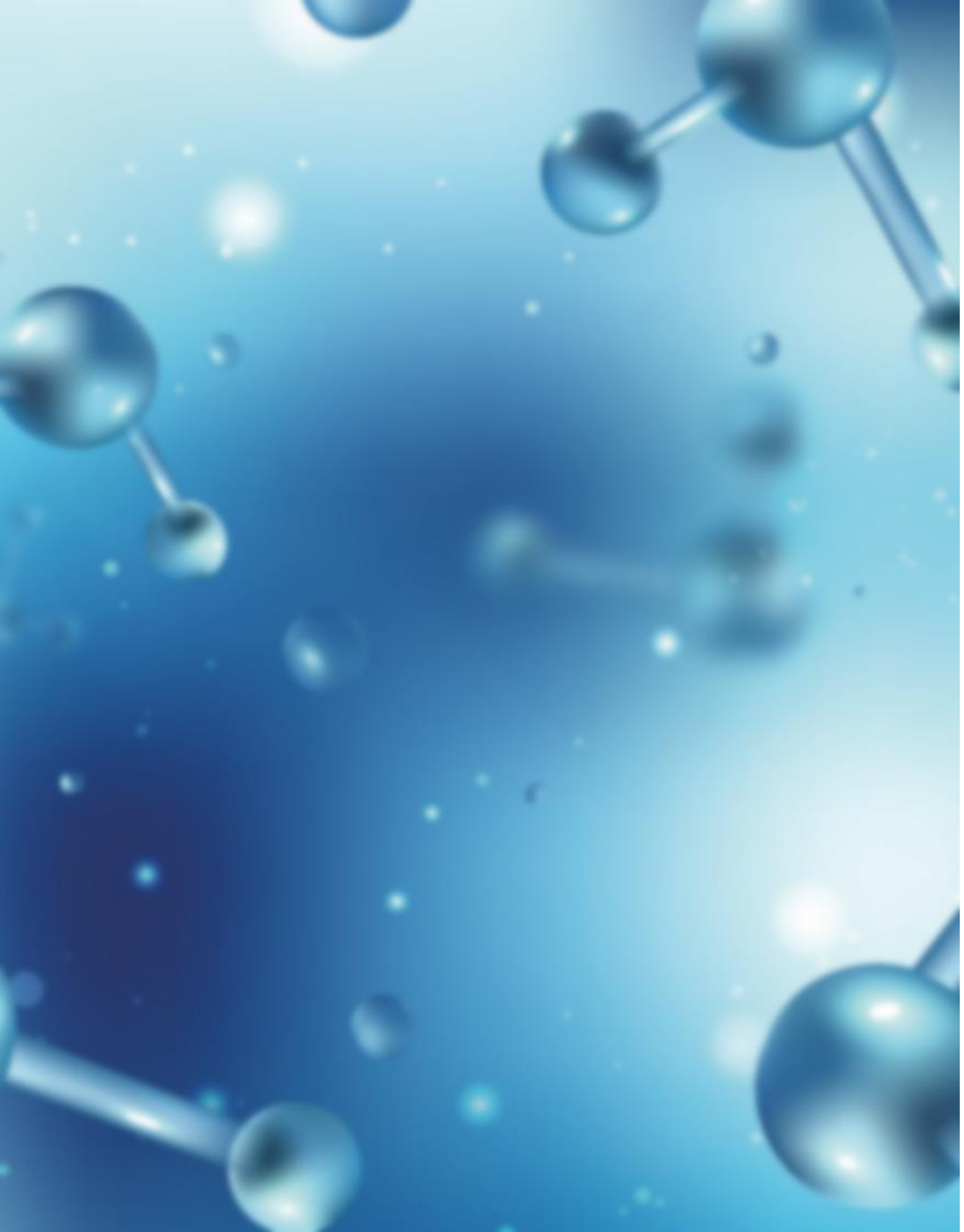


MET4H2

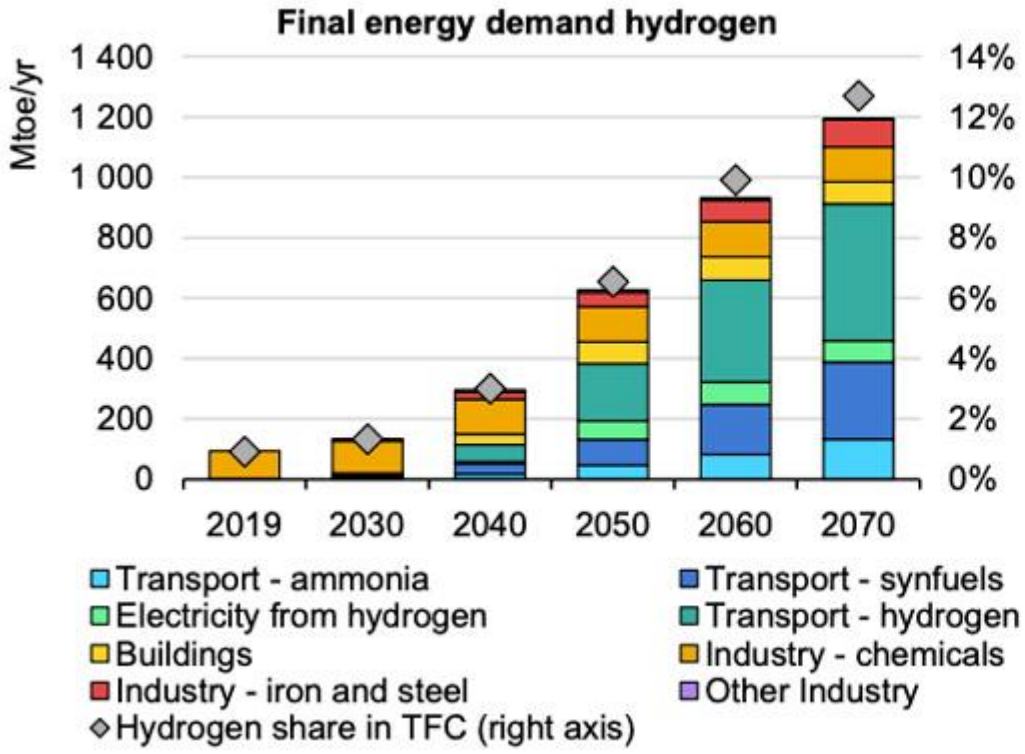
A MEASUREMENT INFRASTRUCTURE FOR HYDROGEN AND BLENDS OF HYDROGEN IN NATURAL GAS

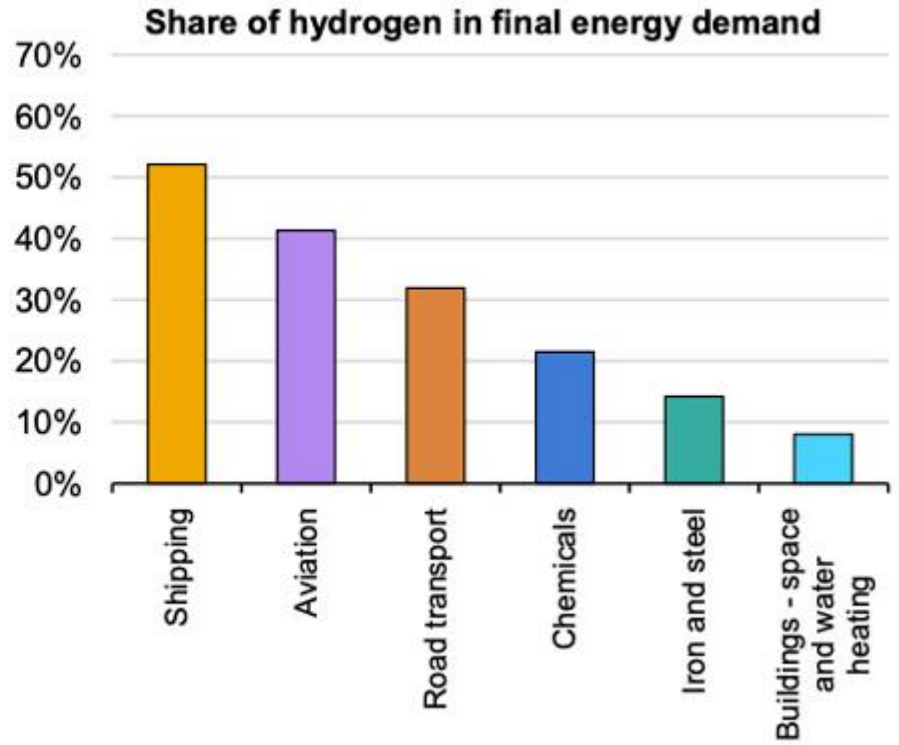
Adriaan M.H. van der Veen (VSL)
6 March 2024
EHEC 2024, Bilbao, Spain

INTRODUCTION AND RATIONALE

- "Unless there are rapid and large-scale reductions in greenhouse gas emissions, limiting warming [...] to 1.5 °C will be beyond reach" [IPCC, 2021]
- European Green Deal (EGD) is Europe's response to decarbonise energy use and to shift to renewable energy sources
- Hydrogen, produced from electricity from renewable sources, is at the centre of this energy transition
- Without access to gas grids, a substantial part of the EU agenda on greening the energy supply cannot be carried out
- Project addresses immediate needs: **safety**, **conformity** with specifications and regulations, and **billing**

WE NEED TO GET STARTED NOW!





Source: IEA, Energy Technology Perspectives, 2020

METROLOGY FOR THE HYDROGEN SUPPLY CHAIN (MET4H2)

- Response to needs when introducing hydrogen into (natural gas) grids
- 27 partners, project started 1 October 2022 and will last 3 years
- Objectives:
  1. To develop calibration and measurement methods in view of **safety, process efficiency and environmental issues**
  2. To develop measurement standards to enable calibration and validation of **flow metering** equipment
  3. To develop and improve measurement standards and methods for validation and performance evaluation of **gas quality measurement** methods for hydrogen, for impurities, e.g., oxygen, hydrogen sulfide, moisture content, and for reactive components such as hydrogen chloride and chlorine.
  4. To develop novel methods for the evaluation of **measurement uncertainty** along the supply chain regarding the measurement of **total quantity, and energy** and impurity content of hydrogen and hydrogen blends.

PARTNERS

MET4H2

VSL National Metrology Institute

BAM Bundesanstalt für Materialforschung und -prüfung

Bundesamt für Eich- und Vermessungswesen

CEM Centro Español de Metrología

CEAME exadébit SA

Český metrologický institut

le cnam Conservatoire national des arts et métiers

DTU Danmarks Tekniske Universitet

DFM

Eidgenössisches Institut für Metrologie

Environment Park Parco Scientifico Tecnologico per l'Ambiente

FORCE Technology

GERG The European Gas Research Group

INRiM Istituto Nazionale di Ricerca Metrologica

Justervesenet

Laboratoire national de métrologie et d'essais LNE

Nippon Gases

NORCE

NPL

Politecnico di Torino

PTB Physikalisch-Technische Bundesanstalt Nationales Metrologieinstitut

RISE Research Institutes of Sweden

SICK Sensor Intelligence.

TÜV SÜD

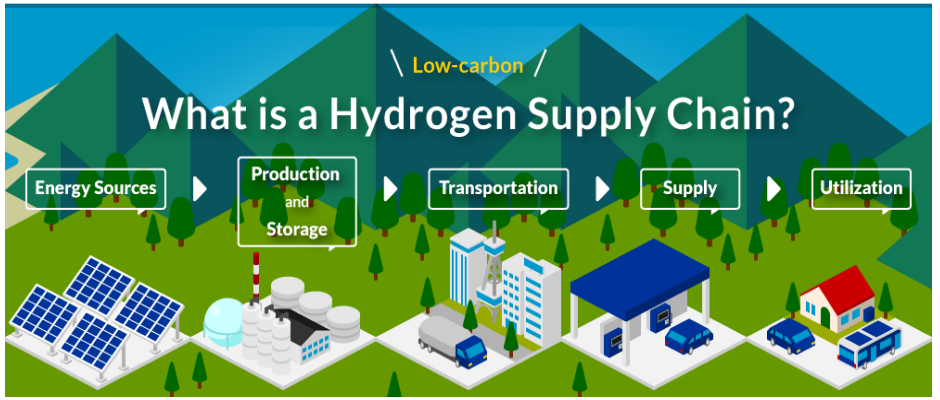
Univerza v Ljubljani

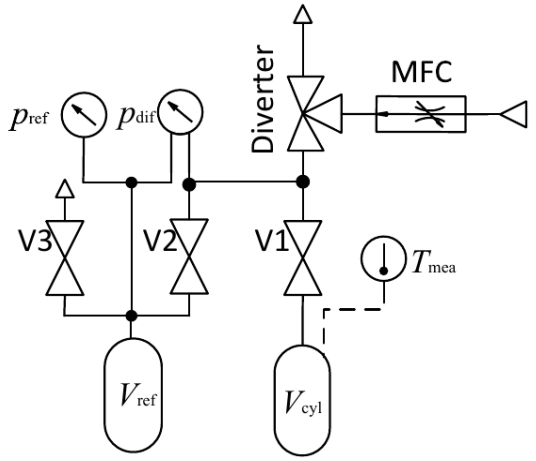
VTT

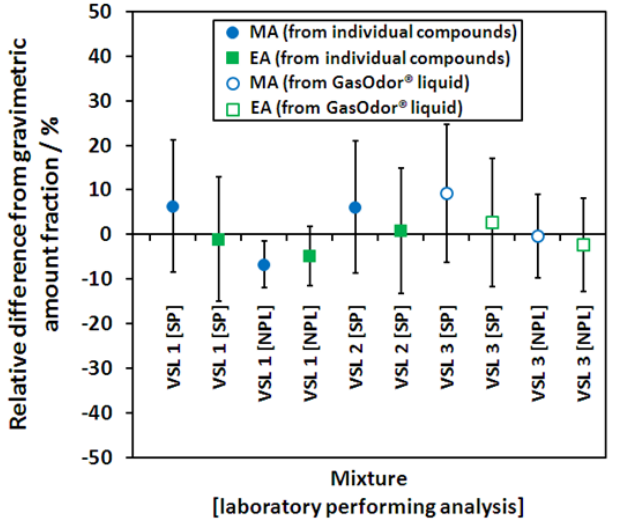
CAE zero carbon

HEALTH, SAFETY AND ENVIRONMENT (WP1)

- Primary standards for leak flow rate measurements (10^{-6} to 10^{-9}) mol s^{-1}
- Characterisation methods for permeation analysis of sealings, liners etc. at (-40 to 120) °C, (0.1 to 10) MPa, (10 to 90) % RH
- Validation protocols and test rigs for hydrogen sensors (hydrogen and impurity content)
- Measurement standards for measuring odorant levels in hydrogen-enriched natural gas and hydrogen (sulfurous and sulfur-free odorants)

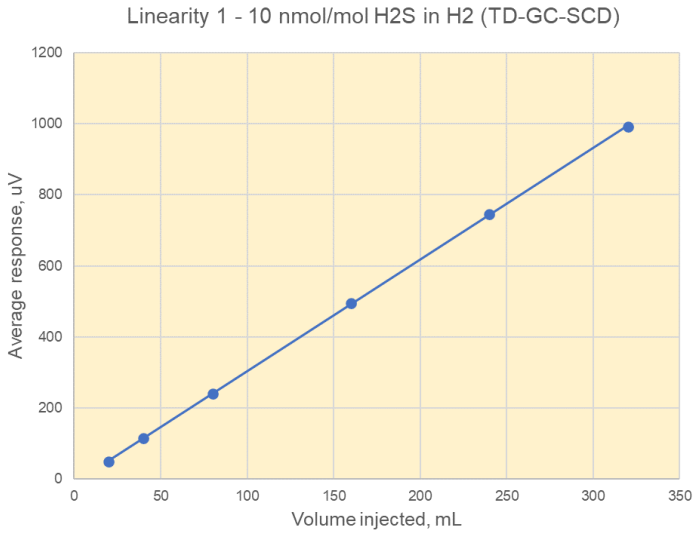




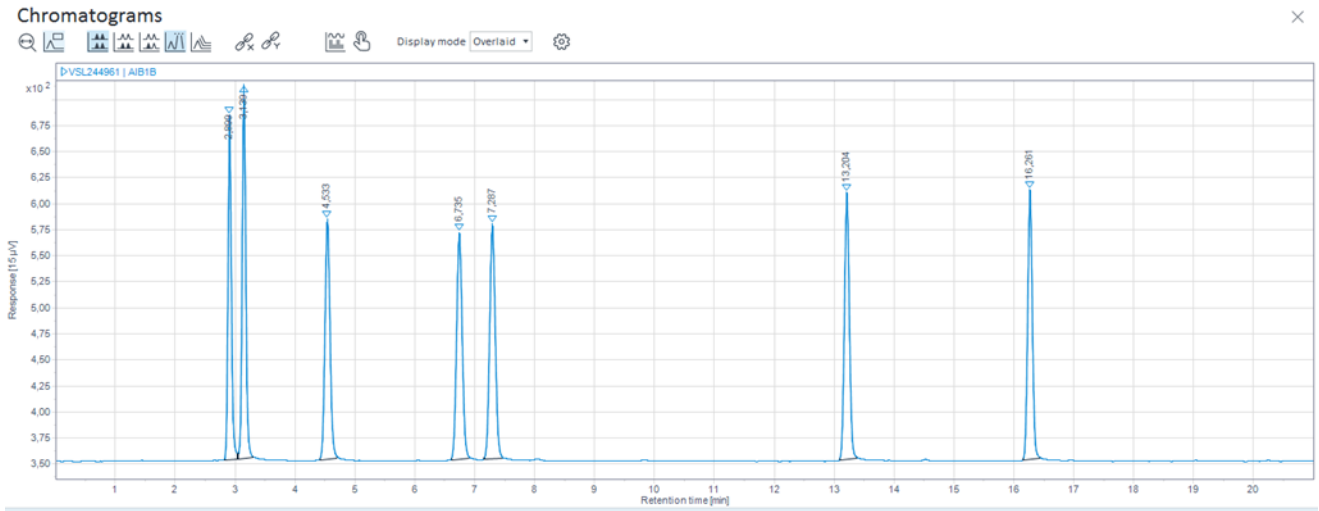


GAS STANDARDS FOR SULFUR COMPOUNDS IN H_2

- H_2S, COS, methyl mercaptan, ethyl mercaptan, DMS, DES, THT
- Method validation (TD-GC-SCD) for 1 – 100 nmol/mol
- Gravimetric preparation of gas standards 10 nmol/mol to 1 µmol/mol
- Dynamic dilution gas standards to reach 1-4 nmol/mol
- Collaboration with pre-concentrator manufacturer
- Matrix effects of up to 1.5 % in blends (CH_4/H_2)

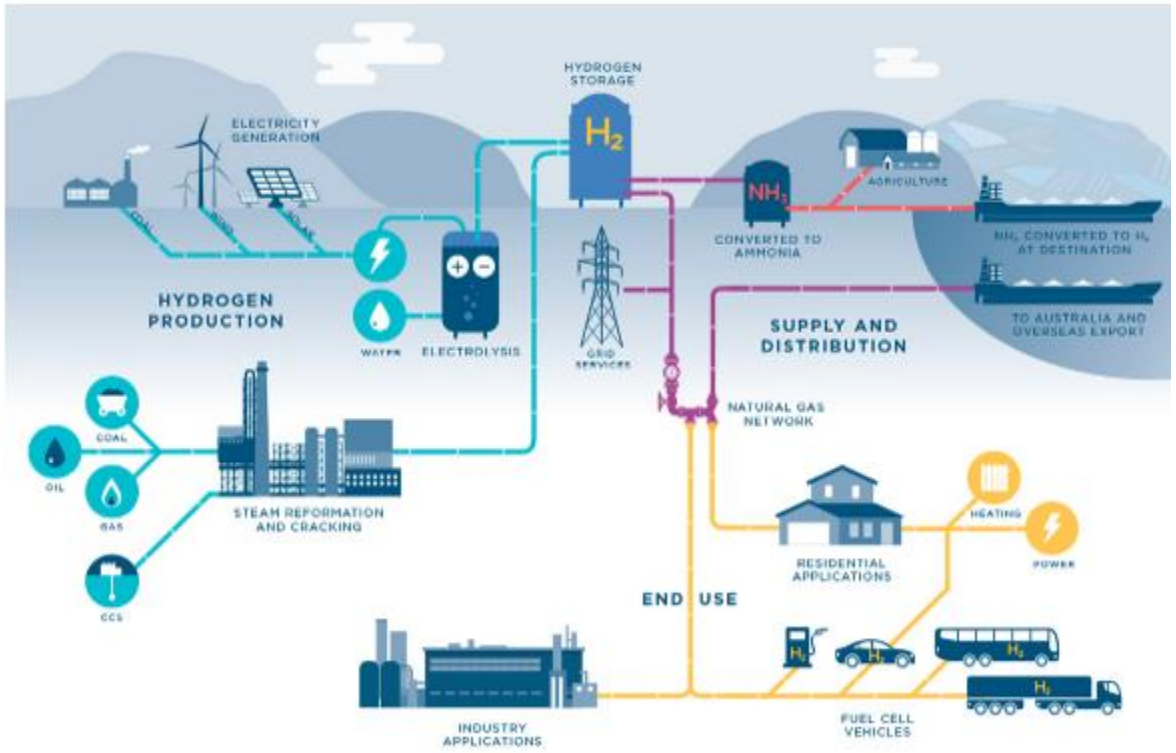


Grade A	2-3 µmol/mol
Grade D	4 nmol/mol



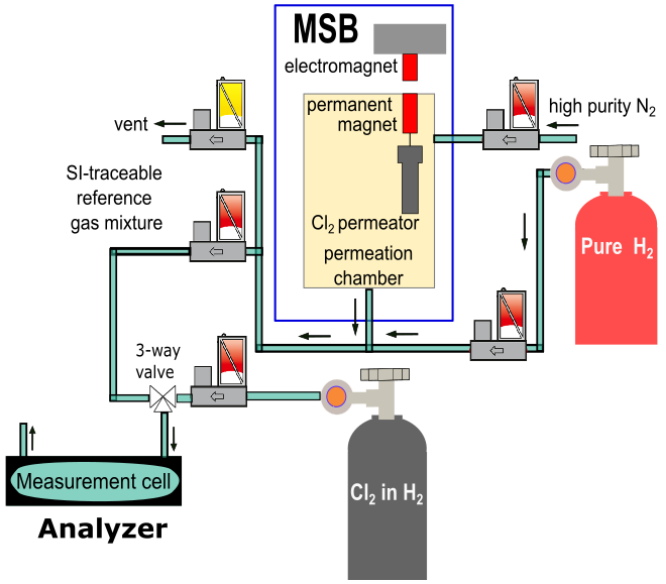
FLOW MEASUREMENT (WP2)

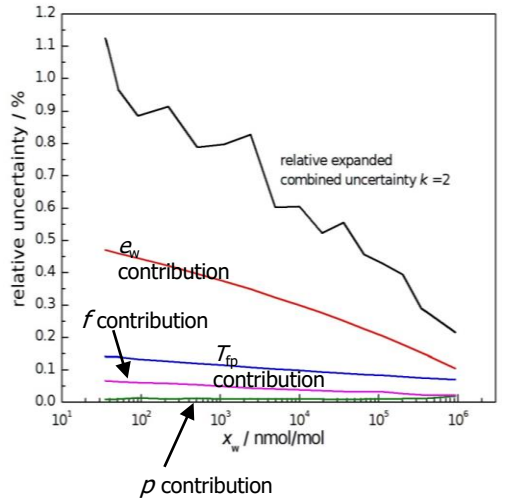
- Overview of the state-of-the-art in flow metering of hydrogen and hydrogen blends
- Intercomparison of flow measurement standards for hydrogen-enriched natural gas
- Flow standards for domestic gas meters for hydrogen, including assessment of impurity impact (up to 2 %)
- Development of metrological traceability chains for large-scale hydrogen transportation



HYDROGEN QUALITY (WP3)

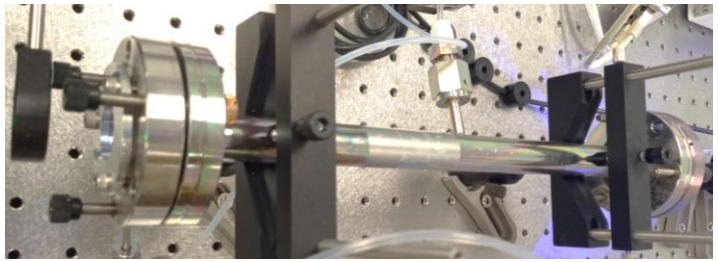
- Development of gas sampling methods for online and offline use
- Humidity standards for the amount fraction water in hydrogen (up to 6 MPa)
- Measurement standards for impurities typical for alkaline electrolysers (e.g., chlorine, hydrogen chloride, and water)
- Measurement standards for hydrogen quality during transportation (e.g., odorisation compounds, ammonia)

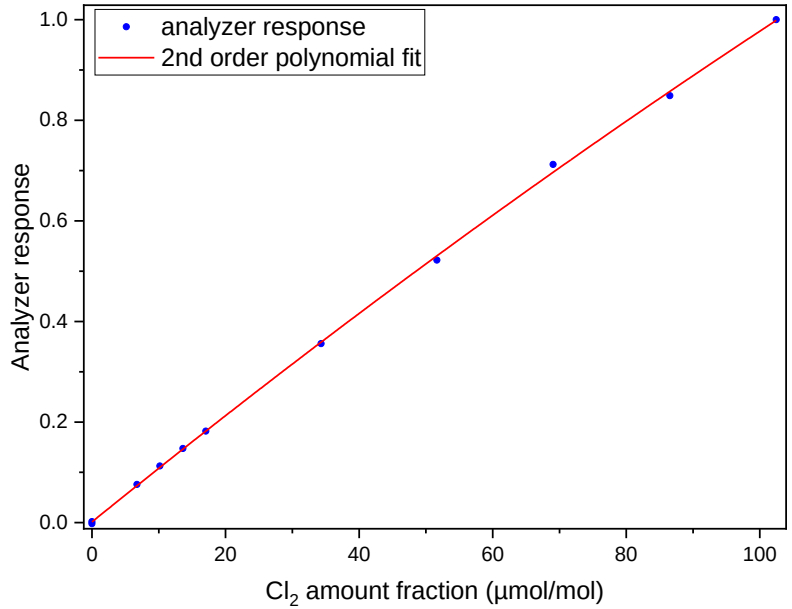




REFERENCE GAS MIXTURES CHLORINE (CL_2) IN N_2 OR H_2

- Developed measurement method (CEAS) for Cl_2 in N_2 or H_2
- Prepared 10 µmol/mol Cl_2 gas mixtures in N_2 (2×) and H_2 (2×) in 10 L cylinder.
- Stability study just started (first points N_2 matrix: loss of -10%)
- Comparison with permeation system (planned)

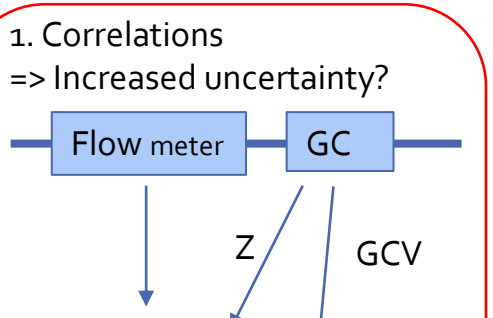




UNCERTAINTY IN FISCAL METERING (WP4)

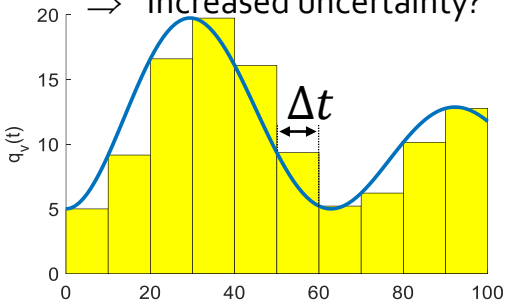
- Development of a framework for the uncertainty evaluation of the total quantity and energy provided
- Evaluating serial correlation in flow and energy
- Uncertainty of approximating the time-integration by a summation
- Risk: assuming independence makes that uncertainty shrinks with more observations than actually justified
- At the end of the day: non-credible uncertainties

1. Correlations
=> Increased uncertainty?



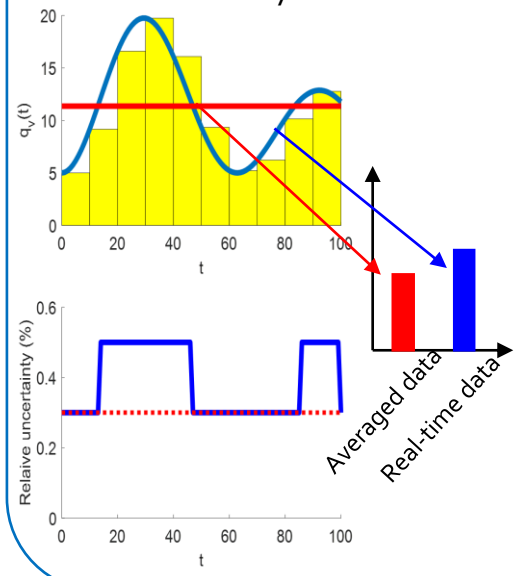
$$E = V \frac{P T_b Z_b}{P_b T Z} \times H_b$$

2. Integration over time
$\Rightarrow$ Increased uncertainty?



$$\int_{t_0}^{t_1} q_v(t)dt \neq \Delta t \sum_{i=1}^{N} q_{v,i}$$

3. Fluctuation in flow rates etc, but average values applied => Increased uncertainty?

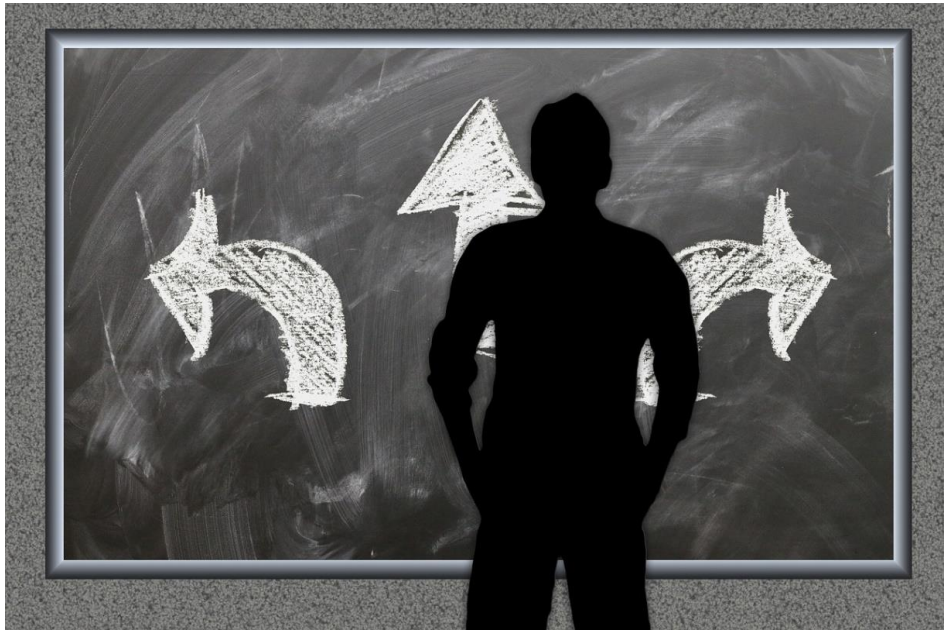


FISCAL METERING

- Research shows the necessity to include dependencies in the uncertainty evaluation
- Current uncertainty evaluations unrealistic and seriously underrating the actual performance of measuring systems
- Behaviour of the improved models more realistic:
  - More fluctuations = larger uncertainty
  - Reading one meter several times does not (meaningfully) decrease uncertainty
- Output will be offered to ISO/TC193/WG7 Energy measurement and to OIML TC8/SC7 Gaseous fuels for updating ISO 15112 and OIML R140
- Methods will be published in a “best practice guide” supplementing existing guidance

CONTRIBUTIONS TO STANDARDS

1. OIML R140 Measuring systems for gaseous fuel
2. OIML R137 Gas Meters
3. ISO 15105 Plastics — Film and sheeting — Determination of gas-transmission rate –
4. ISO 2782 Rubber, vulcanized or thermoplastic — Determination of permeability to gases
5. ISO 14687 Hydrogen fuel quality — Product specification
6. ISO 21087 Gas analysis — Analytical methods for hydrogen fuel — Proton exchange membrane (PEM) fuel cell applications for road vehicles
7. ISO 16664 Gas analysis — Handling of calibration gases and gas mixtures — Guidelines
8. ISO 15112 Natural gas — Energy determination
9. ISO/AWI 19880-9 Gaseous hydrogen — Fuelling stations — Part 9: Sampling for fuel quality analysis



MET4H$_2$

Thank you for your attention!

Interested? Contact us at

avdveen@vsl.nl !

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